MULTI-POINT SEAT BELT

CROSS REFERENCE TO RELATED APPLICATIONS

This is a divisional application of the US-serial number 09/554,463 related to an international application number PCT/DE98/03270 (WO 99/24294, European Patent EP 1 037 773 B1, German Patent DE 197 49 780 C2) filed Nov. 10, 1998.

BACKGROUND OF THE INVENTION

1. Field of the Invention:

It is an object of the present invention to ensure the restraint of passengers of a transport system, while enhancing the user-friendliness and convenience, and to lower all acceleration-dependent forces imposed on them in order to enhance the survival chance in the event of any accident (front-, side-, rear-end collision and/or rollover or pile up/mass collision) or during in-flight turbulence.

2. Discussion of the Prior Art:

It is known in the prior art to provide for a passenger of a transport system

- a seat-belt-turning mechanism guiding a shoulder belt portion;
- a three-point seat belt (safety belt or lap-shoulder seat belt assembly), mounted in the motor vehicle, consisting of a shoulder belt extending across the upper part of his body and of a lap belt extending across the lower part of his body;
- a two-point seat belt, mounted in the aeroplane, acting as a lap belt extending across the lower part of his body; and
- a suspender- (waist-) belt consisting of several pieces (belt-members).

In order to formulate in single terminology a generalized definition is presented for the proper term:

Definition:	**Proper Term:**
"Transport system"	Motor vehicle or train or ship or aeroplane
"Stiff first transport-system	Floor **6** of the transport system adjacent to a first seat-side

member"	SR (**Fig.** 1) or seat-cushion frame at the first seat-side or mid-tunnel (not drawn) of the motor vehicle adjacent to the first seat-side.
"Stiff second transport-system member"	Floor **6** of the transport system adjacent to a second seat-side SL or seat-cushion frame at the second seat-side or post section **91** (**Figs.** 13, 14) of the motor vehicle adjacent to the second seat-side or side rail of the motor vehicle adjacent to the second seat-side
"Stiff third transport-system member"	Floor **6** of the transport system adjacent to the second seat-side or seat-backrest frame at the second seat-side or post section adjacent to the second seat-side.
"Shoulder-belt-portion deflector"	Belt deflector **5, 5a, 5b** or D-ring **12** (**Figs.** 1, 13, 13a)

It is well known to provide different restraint systems in vehicles, predominantly, three-point seat belts in various types for seats. Evidently, when both shoulders of a passenger, conventionally belted, are not restrained in the event of an arbitrary collision with another vehicle in any direction, shown in **Figs.** 3, 4 and 7, the unrestrained shoulder can always move and/or rotate freely, thereby resulting in severe/fatal injuries in real-world accidents when

- the head crashes into the steering wheel and/or window pane and/or
- the airbag crushes the head, which, loaded by the forces related to pitch-acceleration $\ddot{U}_H$, yaw-acceleration Ö, longitudinal and/or lateral acceleration, is in "oop" (out of position).

Moreover, by the definition of „submarining" the belted passenger submarines (slips downward) under his seat belt thus negating the protective effect of the seat belt.

It is well known to provide two-point or lap seat belts for aeroplane seats as well as mid-portion of the rear seats of motor vehicles. This lap seat belt is far less effective than a three-point seat belt. Due to very large accelerations during a turbulence-related flight the protective effect is very low.

A substantially improved protection is proposed by two different configurations of a one-piece seat belt, exemplified by DE 26 02 875 A1 (**Figs.** 8 to 10). An „X-shaped" restraint is arranged by extending both shoulder belts crosswise over the upper part of the body while the lower part of the body is restrained by the lap belt. Each end of the one-piece seat belt is

connected to a belt retractor, fastened in the seat backrest. Two grab rings, positioned to the headrest, move along the belt. A single or double „X-shaped" configuration is defined by pulling a pair of grab rings and belt portions over the head, shoulders and head rest and engaging them in the corresponding hooks. Due to such intricate operation the seat belt remains unused.

Both harness restraint systems ref. to US 4,488,691 and US 4,738,413 are well-known as suspender belts. Each belt portion of the suspender belt must always be adjusted to an appropriate length depending on the size of the passenger. In general, suspender belts are not popular because finding all the belt portions and connecting all the attachment ends to the release device is a lengthy process, especially in the dark. Moreover, all the belt portions make an untidy impression and are not beneficial for sales.

The biggest drawback is the failure of the restraint. When the belt force exceeds 24,000 N due to lack of vibration-dampening energy absorbers in real-world accidents the passenger are severely/fatally injured. Moreover, he frees himself out of the restraint because the belt elongates at a force-dependant rate over 25 %, shown in Fig. 6 of PCT/US99/13362 (US 09/098,294). Despite being properly restrained and properly seated on a child-seat, perfectly secured to the rear seat, a six-year old kid freed himself out of the restraint and was ejected out of a Toyota Yaris, travelling at 100 km/h, when it laterally slammed into a concrete wall. The accident report "U211002" is incorporated herein.

Ref. to US 4,738,413 a harness restraint system comprises a pair of shoulder belt portions, extending crosswise in an X-shape over the upper part of the body of a crew member, a pair of lower-body belt portions, laterally sustaining the lower part of the body, a pair of leg belt portions, encircling the legs and a single-point release device, which holds the attachment ends of all the belt portions and releases them in a single operation.

Ref. to US 4,488,691 a harness restraint system comprises a pair of shoulder belt portions, extending crosswise in an X-shape over the upper part of the body of a crew member, a pair of leg belt portions, restraining the legs and a release device, which holds the attachment ends of all the belt portions and releases them in a single operation.

US 6,375,270 B1 teaches a seat belt (harness) restraint system, comprising an outboard belt, provided with an outboard buckle member, an inboard belt, provided with an inboard buckle member including a connect mechanism, and belt retractors, provided for all four belt ends. In similar fashion, a harness restraint system ref. to US 6,076,894 comprises a pair of shoulder

belts, each provided with a belt retractor, a pair of lap belts, both provided with a common belt retractor, an outboard buckle member, provided for the outboard lap- and shoulder belts, and an inboard buckle member, provided for the inboard lap- and shoulder belts. When the outboard buckle member is plug-in connected to the inboard buckle member, an „X-shaped" configuration is formed by extending both belts crosswise over the upper part of the body of the passenger and the lower part of the body is restrained.

US 4,652,053 discloses a safety belt system, comprising a pair of shoulder belt portions, restraining only the shoulders of the passenger by means of a pair of upper and lower attaching units, and a lap belt portion, restraining the lower part of the body by means of a lap attaching unit. A pair of rotatory members of the upper attaching unit, when rotated, adapts the distance between the shoulder belt portions to the shoulder width of the passenger. A pair of handling members of the lower attaching units, when rotated, adjusts the length of shoulder belt portions to perfectly restrain the shoulders. Only a butler, standing behind the passenger, could accomplish this time-consuming job. If the car catches fire, the passenger will be burnt alive. For sure, no car company would install such intricate, life-threatening systems.

US-Re 34,051 teaches a safety belt system, comprising a locking device, a pair of shoulder-, lap belt portions and pivot arms, having a pair of second wheels, meshing with the corresponding first wheels, connected to each other by a shaft, laterally located in the lower portion of the seat backrest. One end of each shoulder belt portion is arranged in the seat backrest on the top edge and the others are connected to the free ends of the lap belt portions by a male and female member of the locking device.
Ref. to Figs. 5 and 6 of US-Re 34,051 the cross section of the pivot arm is a little larger than that of the lap belt and the lap belt is arranged along in the pivot arm. This feature is redundant. The flexible pivot arms, serving as the lap belts, can take the function thereof. Under the premise that the lap belts (pivot arms) fit the circumference of the passenger, he is restrained when the pivot arms, located at the sides of the seat backrest in the home position, are moved downwards into the operative position and the male and female members are connected to each other. Because each lap belt has a fixed length, the total length of the lap belts together is too short for an obese passenger and too long for a skinny passenger, who, being loosely restrained, is subjected to submarining. When the belt is loaded up to 24,000 N the wheels and/or the pivot arms are totally deformed.

DE-OS 23 45 847 addresses a height-adjustable upper belt deflector of a shoulder belt portion of a three-point seat belt. This deflector can be adapted to the height of the restrained shoulders of the passenger by means of a device, moved by a knob along the rails of the belt deflector. The overall stylish impression is spoiled by the belt deflector, rails and device with the knob, all mounted to the seat backrest, and is not beneficial to sales. Moreover, a passenger, sitting on a seat next the one that is equipped with the belt deflector, device and knob, is severely/fatally injured when his head crashes therein.

According to the Claim No 2 of DE-OS 28 13 888 a four-point seat belt for a passenger seated in the rear, defined by the shoulder and lap belt portion of a three-point seat belt and an upper shoulder belt, is made from one piece. Each belt is guided by a belt deflector, adjacent to the lower part of the body of the passenger, and fastened to the vehicle frame. The end portions of the shoulder belt portion and the upper shoulder belt are provided with belt retractors, attached to the seat backrest. In an attempt to step out the passenger has to lower the upper part of his body in order to slip underneath the upper shoulder belt which cannot be removed.

For convenience the belt deflector of the upper shoulder belt is replaced with a latch plate and a corresponding buckle assembly, fastened to the vehicle frame.

DE 196 29 878 A1 teaches a four-point seat belt, comprising two independent three-point seat belts, each having a belt retractor, latch plate, belt deflector and buckle assembly.

US 3,977,696 discloses a four-point seat belt, comprising a three-point seat belt and an upper shoulder belt, both of which, provided with belt retractors, are guided in two rails and driven by electrical motors of a heavy device. When the vehicle roof is totally deformed in a rollover-accident the heavy device crushes the passenger into death.

US 5,123,673 discloses a four-point seat belt, comprising a three-point seat belt and an upper shoulder belt, both of which are provided with belt retractors. An intricate, automatic release device facilitates the release of both buckle assemblies, each equipped with an actuator to release them, regardless of which one is manually released first. When an MB 200 crashes into the vehicle door of an MB S in the city of Geisenheim, a lateral intrusion of about 80 cm is measured. The accident report "U170199" is incorporated herein. When used, the buckle assembly, actuator and other parts, all of which face the totally deformed vehicle door, are

destroyed. Hence, the other one does not function. The severely injured driver remains restrained. This rescue workers can't evacuate him within seconds.
In the NHSTA side crash test, which, currently legislated, idealizes an SUV crashing at an angle of 30^0 into a door or vehicle side, the buckle assembly, actuator and other parts are destroyed.
A complicated latch-plate-feeding device, installed to the side of seat cushion, moves forwards to present the latch plate of the three-point seat belt to the passenger, after having sat down. This device, facing the vehicle door totally deformed in a side crash, is destroyed.

US 5,411,319 discloses a four-point seat belt, comprising two independent three-point seat belts, having a common lap belt portion. Two end belt portions of both three-point seat belts are projected through the seat backrest and attached to a pair of belt retractors, provided with a pair of supporting pieces, which are arranged in a pair of seat rails, are retained thereby and are moveable therealong with the seat when the latter is longitudinally adjusted.

According to the above-mentioned patent docs and appls US 3,977,696, US 5,123,673, US 5,411,319, US 6,076,894, US 6,375,270 B1, DE-OS 28 13 888 and DE 196 29 878 A1 the „X-shaped" configuration, formed by extending both belts crosswise over the upper part of the body, has, in general, the following drawbacks in the event of an accident:

D1. Exemplified in US 6,375,270 B1, all four belt portions of the outboard and inboard belts are retracted to different lengths and blocked by their respective belt retractors within milliseconds in an accident.

D2. Under the load of the same belt force in a front collision the deformation of the seat backrest, wherein both belt ends are fastened, is larger, thus increasing the forward motion. Furthermore, it is impossible to attach a vibration-dampening energy absorber because all four belt ends are occupied.

D3. Exemplified in US 5,411,319, the belt user has to depress two release buttons to release the respective main latch plates **9** from the main buckle assemblies. This two-click operation causes discomfort and hinders rescue work. See countermeasures by means of a single master release button, mentioned below.

A one-piece seat belt **1** (**Fig.** 1) ref. to DE-OS 28 13 888 is equipped with two belt retractors (not drawn), fastened to both belt ends in the seat backrest, and a belt deflector **17**, anchored to the seat-cushion frame **3.3** of the mid-portion of rear seat. The feature, proposed for a child, has the following drawbacks:

D4. When the release button **84** is depressed, the first shoulder belt portion **1.1** gets entangled around the neck of passenger. For the operation of restraining and extending both belt portions into the „X-shaped" configuration, the passenger must lower his head first.

D5. Because all belt ends are occupied, it is impossible to attach vibration-dampening energy absorbers and to adjust the belt to the size of an upper part of the body **95** of an adult.

Generally, a child-seat is fastened by four auxiliary belts to the seat. Despite the „X-shaped" configuration of a one-piece seat belt to restrain a child, sitting in a child-seat, ref. to FR 2 342 872 A1 the problems, associated with the retraction of four auxiliary belts, submarining and energy absorption, remain unsolved in an accident.

Till now, trains, school buses and buses are not provided with restraint systems.

US 6,145,881 discloses a seat-belt tensioner, mounted on the top edge of a seat backrest. In an accident its pyrotechnic piston and cylinder assembly pulls the shoulder belt portion upwardly away therefrom in order to remove slack from the lap- and shoulder belt portions, but both shoulders become unrestrained. As a result, the passenger frees himself from the restraint in a rollover-accident.

When having measured the sound of an inflated airbag of VW Golf IV at an average level of 165 dB Dr. Hohmann from a Swiss Insurer found out the high sound level is responsible for hearing damage. His investigation report is incorporated herein. Beyond doubt, the explosion of the pyrotechnic unit, located very close to the ear, results in hearing damage or deafening. Moreover, the frame of the seat backrest must be reinforced and the bulky seat-belt tensioner needs space and impairs the overall seat design. Till now cars are equipped with seat-belt tensioners, installed beneath the seats or in the B-post sections in order to insulate the sound and avoid hearing damage.

A D-ring ref. to DE 40 10 452 A1 is in contact with the shoulder belt, when the passenger is thrown forward, but it is moved up to intercept the head, when the passenger is thrown backward.

Under constraint of great deformation of the post section, in which an extending belt portion **1.4** of the three- or multi-point seat belt **1e, 1**, equipped with a belt retractor **13**, having a clamping device, is arranged (**Figs.** 1, 2), the shoulder belt portion, loosely guided by a conventional height-adjustable D-ring **12**, strangulates the neck of the belted passenger and/or injures the aorta of his neck in real-world side crashes, causing instant death.

US 5,599,070 teaches a seat-belt-turning mechanism, fixed to the seat backrest on the top edge and comprising eight parts, one of which is a turning member, by which the shoulder belt portion **1.2** is guided and turned into an extending belt portion **1.4**, which is guided by a sheath and connected to a belt retractor, fixed to a frame of the seat backrest. The height-adjustable, one-piece belt deflector **5, 5a, 5b** (**Figs.** 1, 13, 13a) is far cheaper and more effective than that seat-belt-turning mechanism with fixed height.

Any belted passenger, lying in a sleeping position ref. to DE 37 41 831 C2, submarines when being loaded by great mass inertia force „S_y" in the direction „L_y" (**Fig.** 12b) in the event of accident.

SUMMARY OF THE INVENTION

Accordingly, the principle object of the present invention is to provide for passengers of a transport system seat belts, each equipped with a belt retractor, solely responsible for retraction, blocking and tightening or for protraction, a lower belt deflector to loosely guide a belt portion and multi-attachment points (multi-points of restraint), and to restrain every passenger in multi-attachment points, in order to lower and distribute the acceleration-dependent loads, shown in **Fig.** 3 and **Tables** 1 to 3, to the multi-attachment points in the event of any accident or during in-flight turbulence. Nowadays, belt tighteners are incorporated into belt retractors, for example, of MB 500 SL in order to save costs, assembly time and space.

A second object of the present invention resides in a single master release button, which, when depressed, releases all latch plates from the buckle assemblies and/or returns the belt-feeding device to the home (resting) position. In emergency cases paramedics and fire-fighters can easily rescue the injured passengers.

A third object of the present invention resides in the conventional three-point seat belt associated with new parts, shown in **Fig.** 2, to serve as a transition product until multi-point seat belts are put into production.

A fourth object of the present invention resides in cost-saving methods of concealing a Vehicle Identification Number from car thieves and absorbing energy.

INDUSTRIAL APPLICABILITY

It should be apparent that the invention provides substantially improved restraint, including the following features:

a) The survival chance is enhanced by the restraint of

* both shoulders and the torso, when the passenger is thrown forward (**Fig.** 4, **Table** 3) and/or subjected to the yaw Ö-acceleration-dependent torque $T_{ö}$, and
* both thighs and the lower part of the body to prevent submarining (**Fig.** 12b).

b) Because the belt retractor is attached to one belt end, a number of sets of vibration-dampening energy absorbers ref. to US serial no. 09/554,464 (WO 99/24292, PCT/DE98/03271, European Patent EP 1 037 771 B1, German Patent DE 197 58 498 C2, CA pending patent 2,314,345) or German Patent DE 197 58 497 C2 can be attached to the other belt end (**Figs.** 11a, 11b, 15), thus gradually absorbing large impact energy below the respective injury-related values and dampening vibration. The inventor of the present application has submitted those patent documents and applications to CIPO as well as USPTO. The vibration-dampening energy absorber consists of a number of clamping elements, having sites of predetermined fracture, and a retaining element, which, fastened to the seat-backrest frame and/or seat-cushion frame, can serve as an integral part thereof.

c) Owing to the different positions of pairs of upper buckle assemblies, in plug-in connection with the respective belt-detachable latch plates **25** (**Fig.** 16), passengers of different body proportions can adjust the belts by themselves. Moreover, the seats, equipped therewith, can be modified to be used by adults or children, thus increasing the rate of seat occupancy in a bus, train or an aeroplane, exemplified in **Fig.** 20.

d) In resting position the shoulder latch plate **2**, in plug-in connection with an assisting buckle assembly **16, 16a, 16b,** fastened to the seat cushion **3.1**, B-, C-post section or seat backrest (**Figs.** 1, 2), is easily accessed by the passenger wanting to use the belt.

e) The seat belt can be equipped with a belt-feeding device, manually operated or by a drive apparatus, for example, hydraulic-piston cylinder unit, electrical motor (not drawn), which enhances the convenience and comfort of the user. This drive apparatus is switched on by a pressure sensor, built to the seat, or an existing switch such as lighting-, door- or touching switch. If the belt is not engaged within a dwell time, a control device is activated to switch off the drive apparatus and to reposition the belt-feeding device in the resting position.

f) For the convenience of the passenger, when stepping out, or for the quick-rescue of the injured passenger in accidents, the master release button **84** of the buckle assembly **9.1** is

depressed to release all latch plates from the buckle assemblies and/or to return the belt-feeding device to the resting (home) position.

g) Use of the height-adjustable shoulder-belt-portion deflector **5b** (**Fig.** 13) or of the shoulder-belt-portion deflector **5** (**Fig.** 1), each upper portion of which is projected through the top edge of the seat backrest, makes the conventional height-adjustable D-ring **12**, attached to the B-, C-, D-post section, shown in **Fig.** 1, unnecessary. If the shoulder-belt-portion deflector **5, 5b** is not height-adjustable but movable, it can be connected to vibration-dampening energy absorbers, ref. to US-serial number 09/554,464 (EP 1 037 771 B1, DE 197 58 478 C2, CA pending patent 2,347,040), which absorb energy and dampen vibration when the shoulder belt portion moves it up.

In another embodiment the shoulder-belt-portion deflector **5a** (**Fig.** 13a) can be rigidly attached to the head rest **3.6a**. Any adjustment of the height of the head rest **3.6a** to the head automatically adjusts the height of the shoulder-belt-portion deflector to the shoulder.

h) Owing to the different positions of anti-submarining buckle assemblies, in plug-in connection with the respective anti-submarining latch plates, passengers of different body proportions, thighs and weight can adjust the length of the anti-submarining belt portions **1.3R, 1.3L** by themselves. In contrary to Volvo's WHIPS, the adult seats, equipped therewith, can be modified for children and vice versa, thus increasing the rate of seat occupancy in a bus, train or an aeroplane, exemplified in **Fig.** 20. In another embodiment the length-adjustable belt of the anti-submarining seat belt assembly **8b, 8c** facilitates, for example, a female passenger to adapt the belt length to her long gown or to herself, when lying in sleeping position (**Figs.** 1, 12b).

For safety reasons and easy access the anti-submarining latch plates **11, 25**, when not being used, are stored in a storage box **25.5** (**Fig.** 20). The belt-detachable anti-submarining latch plates **25** (**Figs.** 12b, 16) are attached to the lap belt portion when needed.

For the convenience of the passenger, when stepping out, or for a fast rescue of the passenger injured in an accident, the master release button **84** of the buckle assembly **9.1** is depressed to release all latch plates from the buckle assemblies.

BRIEF DESCRIPTION OF THE DRAWINGS

A number of embodiments, other advantages and features of the present invention will be described in the accompanying tables and drawings with reference to the xyz global coordinate system:

Table 1 shows test data such as left / right thigh-force, belt force and pitch-angle of driver and co-driver in 50% offset crash test of several European vehicles at crash speed of 55 km/h.

Table 2 shows yaw angle O of driver / co-driver in a 50% offset crash tests.

Table 3 shows test data of the safest child-restraint system Chico Shuttle® at the converted velocity of 55 km/h in comparison with the safest vehicle among them listed in **Table** 1.

Fig. 1 is a perspective view of a 1st embodiment of a height-adjustable shoulder-belt-portion deflector **5**, of anti-submarining buckle assemblies **7, 8, 8a to 8d**, attached to the seat, and of a seat with buckle assemblies attached to the seat backrest and seat cushion as well as of a 1st embodiment of a restraint system consisting of a multi-point seat belt **1**, shoulder-belt deflector **5**, D-ring **12**, latch plate **11** moveable along the lap belt, shoulder latch plate **2** of belt end portion, in the direction of arrow „Z" in plug-in connection with an upper buckle assembly **4**, and a seat belt in X-shape, formed by crossing the first and second shoulder belt portions **1.1, 1.2**.

Fig. 2 is a perspective view of a seat and of a 2nd embodiment of a restraint system, comprising three-point seat belt **1e,** having a transition latch plate **2**, which will be inserted into a transition buckle assembly **4e** of a shoulder belt **1.11**, pulled in the direction of arrow „Z".

Fig. 3 illustrates load cases I, II and III in z-y plane in the event of a real-world accident.

Fig. 4 is a perspective view of a restrained dummy thrown forward in VW Polo® in a 50% offset crash test.

Fig. 5 illustrates a yaw-acceleration Ö and yaw-angle O of a vehicle about the vertical axis „z_A" in a 50% offset crash test of two identical vehicles.

Fig. 6 illustrates a yaw angle O of vehicle about the vertical axis „z_A" in a 50% offset crash test into a stiff barrier.

Fig. 7 illustrates four collision types „U1" to „U4" ref. to the research work of Institute of Vehicle Safety, a Dept. of German Insurers Association.

Fig. 8 is a front view of a seat belt ref. to DE-OS 26 02 875 in the home position.

Fig. 9 is a front view of a double X-shaped seat belt ref. to DE-OS 26 02 875.

Fig. 10 is a front view of a single X-shaped seat belt ref. to DE-OS 26 02 875.

Fig. 11a is a schematic, perspective view of a 1st embodiment of a buckle assembly **4a**, equipped with release cable **4.2**.

Fig. 11b is a schematic, perspective view of a 2nd embodiment of a buckle assembly **4b**, equipped with an electrical release-motor **4.2b**.

Fig. 12a is a perspective view of a 1st embodiment of a belt-catching member **20.7a**.

Fig. 12b is a perspective view of a 2nd embodiment of a belt-catching member **20.7** and of a anti-submarining latch plate **11, 25** of a lap belt portion **1.3** in plug-in connection with the anti-submarining buckle assembly **8**.

Fig. 13 is a perspective view of a 1st and 2nd embodiment of a belt-feeding device and spatially-adjusting belt-feeding device **20a** from the resting position to the operative position and of a height-adjustable shoulder-belt-portion deflector **5b** as well as of a 2nd embodiment of a height-adjustable belt deflector **5b** having a locking handle **5.2**.

Fig. 13a is a perspective view of a 3rd embodiment of a shoulder-belt-portion deflector **5a** fastened to a head rest **3.6a**.

Fig. 14 is a schematic view of the 2nd and a 3rd embodiment of spatially-adjusting belt-feeding devices **20a** and **20b** in kinematics from the operative position to the resting position in x-y plane.

Fig. 15 is a schematic, perspective view of a seat backrest, equipped with a second belt retractor **13a**.

Fig. 16 is a schematic, perspective view of a belt-detachable U-shaped latch plate **25** and a 1st and 2nd embodiment of a height- and width-adjusting mechanism **27, 27a**.

Fig. 17 is a cross-sectional view of the 1st embodiment of the height- and width-adjusting mechanism **27** along the line I-I of **Fig.** 16.

Fig. 18 is a cross-sectional view of the height- and width-adjusting mechanism **27** along the line II-II of **Fig.** 17.

Fig. 19 cross-sectional view of the 2nd embodiment of the height- and width-adjusting mechanism **27a** along the line I-I of **Fig.** 16.

Fig. 20 is a front view of the seat **3a to 3d**, in which the restraint systems **1a to 1d,** storage boxes **25.5** and the anti-submarining seat-belt assemblies are integrated, for passengers of different weights, different circumference of thighs and different body proportions (sizes), where anti-submarining buckle assemblies are in plug-in connection with the anti-submarining latch plates **11, 25**.

Fig. 21 is a side view of a 1st embodiment of a property of limited energy absorption **70** of the multi-point seat belt **1, 1a to 1d** and of a „VIN" **81**.

Fig. 22 is a side view of a 2nd embodiment of a property of limited energy absorption **80** of the multi-point seat belt **1, 1a to 1d** and of the „VIN" **81**.

Fig. 23 is a top view of the 2nd embodiment of the property of limited energy absorption **80** of the multi-point seat belt.

DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

The advantages of the preferred embodiments in the Chap. "INDUSTRIAL APPLICABILITY" are outlined hereinafter with regard to the functions and features thereof.

The method of the present invention capitalizes on the premise that a seat belt is employed to restrain a passenger in at least four attachment points of the seat to distribute all acceleration dependant loads, particularly the yaw Ö-acceleration-dependent torque $T_{ö}$, thereto in an accident, thus ensuring the operation of a single belt retractor to pre-tension (bias) as well as tension the belt, restraining both shoulders, an upper- and a lower part of the body and lowering all the loads, in particular, in co-operation with the energy-absorption when a number of sets of vibration-dampening energy absorbers is put into use. This will be apparent when all forces, imposed on the belted passenger, shown in **Figs.** 3 and 4, are formulated in the event of a front collision, where the loads of the mass D_S of the torso are lowered because

- the forward motion „w_v" is minimized, thus substantially reducing the pitch-acceleration $Ü_H$ and force F_{Hy} of the mass D_H of the head, and
- the yaw-acceleration Ö is minimized, thus substantially reducing the torque $T_{ö}$, imposed on the head. Great torque $T_{ö}$ is the most latent force, responsible for sudden death.

To a great extent massive head injuries can be avoided.

Load case I in z-y plane: The rotating mass D_S rotates about the rotating axis „S" at the pitch-angle U_S and mass D_H about the rotating axis „z" at the pitch-angle U_H in **Table** 1, thereby resulting in the pitch-accelerations $Ü_S$, $Ü_H$ and rotating forces F_{Sy}, F_{Hy}. The addition of both rotating forces yields the force F_V linked to the forward motion w_V of passenger, shown in **Fig.** 4.

Load case II in x-y plane: The upper part of the body is subjected to the torque $T_{\ddot{o}}$, exerted by the yaw-acceleration Ö about the rotating axis „z". When the upper part of the body is restrained in an X-shape, the torque is substituted by a pair of forces.

Load case III in x-z plane: The rotating mass D_S rotates about the rotating axis „S" at the rotating angle U_y and mass D_H about the rotating axis „z" at the rotating angle U_{Hy}, thereby resulting in the rotating accelerations $\ddot{U}_y$, $\ddot{U}_{Hy}$ and rotating forces D_{Sy}, D_{Hy} (not drawn). In a rollover-accident the passenger is subjected to the load F_{Sz}.

Load case IV: In turbulence-related vibrations of an aeroplane the load D_{Sy} together with D_{Hy} takes the form of periodical load $\pm F_{Hx}$, F_{Sz} of $\pm F_{Sz}$, $T_{\ddot{o}}$ of $\pm T_{\ddot{o}}$, S_y of $\pm S_y$ and F_{Sy} together with F_{Hy} of $\pm F_V$.

The restraint system, illustrated in **Fig.** 1, is provided with a conventional belt retractor **13** having a clamping device, housed in the B-, C-, D-post section or in the seat backrest **3.2** at one of both seat-sides SL and SR of a seat and connected to the second belt end EL. The first belt end ER is provided with a shoulder latch plate **2**, which is retained, loosely guided by a lower belt deflector **17**, fastened to the vehicle floor, and inserted into one of the upper buckle assemblies **4, 4a to 4c, 14, 14a, 18, 18a, 18b**, arranged in or to the seat backrest **3.2**. In all embodiments a main latch plate **9** can move along the seat belt **1** between both belt ends EL and ER. When plug-in connecting the shoulder latch plate **2** (in the direction of arrow "Z") to the buckle assembly **4** and the main latch plate **9** to the main buckle assembly **9.1**, an X-shaped restraint of the upper part of the body and both shoulders as well as a restraint of the lower part of the body are accomplished by the first and second shoulder belt portion **1.1, 1.2** and the lap belt portion **1.3**.

In the 2nd embodiment, shown in **Fig.** 2, a transition product, comprising a conventional three-point seat belt **1e** and new parts, has to be invented due to the delay in producing multi-point seat belts **1**. The floor fitting (not shown) is replaced by the lower belt deflector **17**. The first belt end of the lower first shoulder belt portion **1.11** is provided with transition latch plate **2**. The first belt end of an upper first shoulder belt **1.12** and the second belt end are equipped with a transition buckle assembly **4e**, having a transition release button **84c**, and with a second belt retractor **13a**, arranged in the seat backrest **3.2**. Due to the second belt retractor the transition buckle assembly **4e**, acting as the shoulder latch plate **2, 2a** of multi-point seat belt,

is located in a home position on a seat-backrest aperture of the seat at the first seat-side. Hence, the seat-design is not compromised. In a coupling position the restraint in an X-shape is defined by plug-in connection of transition latch plate **2** with the transition buckle assembly **4e**, pulled out from the seat-backrest aperture, wherethrough a transition portion of the upper first shoulder belt is projected. This upper first shoulder belt and the lower first shoulder belt portion **1.11** define the first shoulder belt portion **1.1**. In order to resolve the above-mentioned drawback **D1**, the spring force of the second belt retractor **13a**, to retract the upper first shoulder belt **1.12**, released by depressing the transition release button **84c**, is far less than that of the belt retractor **13**. Although the circumference of the restrained passenger varies, depending on the clothes worn, and the seating-position differs the lower first shoulder belt portion **1.11** always projects through the lower belt deflector **17** at a sufficient length of "l_1" to maintain the function of the belt retractor **13** to retract, to block the belt as well as to release the retracted belt during the journey and the function of the belt tightener (not drawn), incorporated in the belt retractor, to forcefully retract (withdraw) and tighten the belt in an accident. The transition release button **84c** of transition buckle assembly **4e**, arranged to or in the seat, can be controlled neither by release cable **4.2** nor by electrical release-motor **4.2b**. It can only be activated by electrical signals emitted from the master release button **84** when depressed.

The second belt end of upper first shoulder belt **1.12** can be connected either to a coupling fitting **1.2a, 1.2b (Figs.** 11a, 11b, 15) or to the second belt retractor **13a** having a coupling fitting **1.2b (Fig.** 15) in order to receive a number of vibration-dampening energy absorbers to dissipate great impact energy and dampen strong vibration.

In another embodiment an upper first shoulder belt **1.12a** consists of the transition buckle assembly **4e** and a shoulder latch plate **2a** (not shown), similar to latch plate **2 (Fig.** 1), which is plug-in connected to

- the upper buckle assembly **4, 4a to 4c, 14, 14a, 18, 18a, 18b, 18.1 to 18.3**, arranged to the seat backrest, in operative position or
- the assisting buckle assembly **16, 16a, 16b** in resting position.

When motor vehicles are already licensed, modification of different seats and three-point seat belts can easily be accomplished by arrangement of at least one buckle assembly, the lower belt deflector **17**, the second belt retractor **13a** and by a variety of one-piece, detachable,

upper first shoulder belts **1.12a** with different lengths. Furthermore, the latch plate **2a** can be detached from the buckle assembly by depressing the master release button **84**.

A first shoulder belt portion **1.1** is defined by the upper first shoulder belt **1.12a** and the lower first shoulder belt portion **1.11**.

With an expensive modification or in new transport system the convenience and comfort are enhanced by the use of belt-feeding device **20, 20a to 20d**, where the upper first shoulder belt **1.12, 1.12a** with transition buckle assembly **4e** is a part of the belt-feeding device.

Beyond doubt, the three-point seat belt **1e** in plug-in connection with the upper first shoulder belt **1.12, 1.12a** is suited as a temporary solution for the multi-point seat belt **1, 1a to 1d**.

In the above-mentioned embodiments to resolve the above-mentioned drawback **D4** the upper part of the body is restrained by extending the shoulder belt portions crosswise in an X-shape

c1) when at least one shoulder latch plate **2** is plug-in connected to the upper buckle assembly of the seat backrest; *or*

c2) when a shoulder latch plate **2**, arranged to the first belt end ER of the first shoulder belt portion **1.1** of a belt-feeding device **20a**, **20b**, is plug-in connected to the upper buckle assembly of the seat backrest.

The feature ref. to c2) has the advantage that the common practise of operating the conventional three-point seat belt is preserved.

In order to resolve the above-mentioned drawbacks **D2** and **D5** great energy is absorbed and strong vibration is dampened by a large number of vibration-dampening energy absorbers connected to the respective upper buckle assemblies **4, 4a to 4c, 4e, 7, 8, 8a to 8d, 9.1, 14, 14a, 15, 15a, 18, 18a, 18b, 18.1 to 18.3, 19, 19a, 19b, 19.1 to 19.3** (**Figs.** 1, 20) to which latch plates are plug-in connected.

The lower belt deflector **17** comprises a housing having an attachment hole to receive a pin **17.1**. Both members can be made in one piece. If necessary, the pin **17.1** is surrounded by a sleeve **17.2** of plastics, having corrugation or knobs, which is a common part of the conventional D-ring **12**. This D-ring **12** can be replaced by the lower belt deflector **17**. The aperture of the belt deflector **17** to loosely guide the belt portion is dimensioned so as to retain the latch plate **2** in resting position, thus allowing the use as a three-point seat belt.

To prevent the entanglement of the first shoulder belt portion **1.1** behind the seat, particularly when positioned furthest forward, that first shoulder belt portion **1.1** in resting position is intercepted by the belt-catching member **20.7, 20.7a (Figs.** 12a, 12b). When the second shoulder belt portion **1.2** and the extending belt portion **1.4** are arranged to the post section, both shoulder belt portions can also be intercepted by the belt-catching member.

When the seat **3c (Fig.** 20) has a high seat backrest, the curved guide tube **20.1** of belt-feeding devices **20a (Fig.** 13) can be modified to a straight-running operating arm **20.2** of the belt-feeding device **20**.

In the 2nd or 3rd embodiment the belt-feeding device **20a** or **20b** is provided with a height-adjustable belt housing **20.4a** and radial-adjustable tube **20.3 (Figs.** 13, 14). Both devices differ from each other by the position of the guide tubes **20.1** on the seat backrest. Each guide tube can be driven by a drive apparatus, housed in the seat backrest. The guide tube **20.1** of the belt-feeding device **20a** is pivotally attached in a stiff supporting tube **3.61** of the head rest **3.6** with fixed height .

The height of „Δh" of belt housing **20.4a**, having a latch plate **2**, plug-in connected to any buckle assembly **4, 14, 18**, is adjustable when the passenger moves two openings, facing each other, along the operating arm **20.2a**. Alternatively, the passenger can move a handle **5.2**, such as locking handle **27.5** of the height- and width-adjusting mechanism **27, 27a (Figs.** 13, 17 to 19), to adjust the height of „Δh" of the shoulder-belt-portion deflector **5b**.

In order to ensure the operation of pro- and retracting any shoulder-belt portion, arranged in the seat backrest (**Figs.** 8 to 10), is loosely guided by a shoulder-belt-portion deflector which, having a rectangular shape, is usually pressed in a seat-backrest aperture of the seat backrest on the top edge.

The belt-feeding devices **20a, 20b** have to meet the following criteria:

- Passengers can freely get in and out of the vehicle compartment thanks to the distances of „a" and „b" between the post section **91** and operating arm **20.2a (Fig.** 14) in resting position; and
- the device, when rotated, does not interfere with the head rest **3.6** owing to the clearance (height-difference) about „Δh_K" and with the head of the passenger with/without hat **92**.

Regarding the kinematics of the height-adjustable belt housing **20.4a** with the latch plate **2** from the operative position to the resting position, the trajectories of „Ba2" and „Bb" are well

clear of the passenger's head thanks to a radial-adjustable tube **20.3** incorporated into the operating arm **20.2a**. Without the radial-adjustable tube **20.3** the operating arm in the trajectory of „Ba1" would interfere with that hat.

Upon plug-in connection of the latch plate **2** with the buckle assembly **4, 4a, 4b** the belt end ER of belt portion **1.1** is connected to the coupling fitting **1.2a, 1.2b** (**Figs.** 11a, 11b), whereto a number of vibration-dampening energy absorbers is attached to absorb energy and dampen vibration. In a cost-saving embodiment without the latch plate **2** and buckle assembly, the belt end ER of belt portion **1.1** is directly connected to the coupling fitting **1.2a** or **1.2b** (**Fig.** 15) to receive vibration-dampening energy absorbers, the retaining elements of which are fastened to the seat backrest frame **3.4d**. In order to absorb great energy and damp strong vibration during in-flight turbulence or in the accident of a fast speeding car or high-speed train, the belt retractor **13**, coupling fitting **1.2b** of which is connected to vibration-dampening energy absorbers, is moveably attached to the oblong holes of a stiff plate **13.3**, fastened to the seat-backrest frame at the seat-side SR so that the other belt end EL can be exploited to receive additional energy absorbers. In excess of threshold value the belt retractor pulls the clamping elements along the respective retaining elements to absorb energy and damp vibration.

In the 1st to 3rd embodiment (**Figs.** 11a, 11b, 18) the buckle assembly **4a, 4b, 4c** is form- and/or force-locking connected to the seat-frame of the seat.

For the convenience of the passenger when egressing from the vehicle and in cases of emergency the following embodiments of detachment are proposed:
To disconnect the latch plates **2, 11** and/or **25** from the buckle assemblies **4, 14, 14a, 15, 15a** (**Fig.** 1) and pairs of supplement upper buckle assemblies **18 / 19, 18a / 19a, 18b / 19b, 18.1 / 19.1 to 18.3 / 19.3** (**Fig.** 20) of the seat arrangement, particularly for children, as well as from the anti-submarining buckle assemblies **7, 8, 8a to 8d** (**Figs.** 1, 12b), the master release button **84**, when depressed, activates the release cables **4.2** and/or electrical release-motors **4.2b**, which pull the release button **84a** and/or **84b** of the buckle assemblies (**Figs.** 11a, 11b, 18). When depressing the master release button **84** the drive apparatus of the belt-feeding device **20, 20a, 20b** returns the first shoulder belt portion **1.1** from the operative position to the resting position.

In the 1st embodiment (**Figs.** 17 to 19) the height- and width-adjusting mechanism **27** comprises a frame **29**, buckle-assembly unit **18.3, 19.3**, a pair of tubes **27.4**, members **27.5 to 27.9** and a pair of tubes **27.1** having a plurality of vertical locking slots, in form- and force-locking connection with an angle fitting **26a**. The frame **29** consists of a pair of outer tubes **27.3**, a pair of tubes **27.2** and a connecting member of all tubes. The locking handle **27.5** is form- and force-locking connected to the slots of the inner tubes **27.4**.

These inner tubes **27.4**, inserted into the outer tubes **27.3**, are pre-loaded by the tube-springs **27.6**. Each tube-spring **27.6** on a sleeve **27.7**, secured by pin **27.8**, protruding through the holes of the inner tube **27.4**, presses against the spring rest **27.9** of the outer tube **27.3**.

The locking handle **27.5** is in engagement with a pair of vertical locking slots of tubes **27.1**. The locking handle **27.5**, when pulled out from both slots, is detached therefrom. The height of mechanism **27** and buckle assembly can be adjusted

The outer tube **27.3** is provided with a plurality of horizontal locking slots q, r, s etc., drawn with dotted lines, shown in **Figs.** 17, 19.

After the pawl **18.10**, pre-loaded by the pawl-spring **18.5**, is detached from the horizontal locking slot r by its movement in the direction of arrow (**Fig.** 18), the housing **18.12** of the buckle-assembly unit **18.3, 19.3**, form-locking connected to the upper buckle assembly **4c** thereof, can be moved along both outer tubes **27.3**.

Belt-detachable U-shaped latch plates **25** offer the passengers a feature to adapt their body proportions to the appropriate pair of supplement upper buckle assemblies into which the latch plates **25** are inserted (**Figs.** 16, 20). Any belt portion, such as **1.1, 1.2**, is loosely guided thereby, secured by a quick-release pin **25.1** thereof and detached therefrom by pulling the quick-release pin. To adapt a small body proportion of, say, a child, far lower than the upper buckle assembly **4** suited for adults, at least one pair of belt-detachable latch plates **25** are plug-in connected to one of the pairs of supplemental upper buckle assemblies **18 / 19, 18a / 19a, 18b / 19b, 18.1 / 19.1 to 18.3 / 19.3,** arranged to the seat backrest at the first and second seat-side (**Figs.** 1 and 20). For safety reasons and easy access the belt-detachable latch plates **25**, when not being used, are stored and secured in a storage box **25.5** of the seat (**Fig.** 20).

For juxtaposed seats in vehicles, buses, trains and aeroplanes it is recommended to use a single locking handle **27.5** to operate the 2nd embodiment of the height- and width-adjusting mechanism **27a** of each seat **3c**, having, for example, three pairs of openings **18.1 /19.1 to 18.3 / 19.3** to receive a pair of shoulder latch plates (**Figs.** 19, 20).

The frame **29a** consists of two pairs of outer tubes **27.3**, two pairs of tubes **27.2**, a pair of connecting members of all tubes and members **18.3, 19.3, 27.6 to 27.9a, 27.11**, attached to the outer tubes **27.3**.

The locking handle **27.5** is form- and force-locking connected to slots of the inner tubes **27.4** by the pins **27.12**. After inserting these inner tubes into the outer tubes **27.3** the locking plate **27.10** is form- and force-locking connected to the slots of the inner tubes and to the pins **27.12**.

After securing the spring rest **27.9a** by the retaining rings **27.11** and both sleeves **27.7a** by the pins **27.8**, protruding through the holes of inner tubes **27.4** and oblong holes of outer tubes **27.3**, the inner tubes with locking handle **27.5** are pre-loaded by tube-springs **27.6**. The locking handle **27.5**, when pulled out from both slots, is detached therefrom. The height of height- and width-adjusting mechanism **27a** can be adjusted.

In an embodiment the release button **84f** (not drawn), **84e** of free-moving anti-submarining buckle assembly **8b, 8c (Fig.** 1), whose housing is free-moving on the seat cushion and whose length-adjustable belt is fastened to the seat frame, can be controlled neither by a release cable **4.2** nor by an electrical release-motor **4.2b**. Hence, the release button **84e, 84f** can only be activated by an electrical signal emitted from the master release button **84,** when depressed, to remove the protection from submarining.

Because the reel (spool) of the conventional belt retractor can accommodate only a limited length of belt, it is possible that the length of the seat belt for the sleeping position is insufficient. The length-adjustable belt compensates for the length of seat belt **1, 1e** and accommodates the passenger, particularly when being obese, in all positions between the sleeping and normal position.

An anti-submarining buckle assembly **8d**, provided with a release button **84d**, is attached to the front portion of the seat cushion. This feature facilitates the obese passenger or a lady in a gown to restrain the thighs by plug-in connecting the anti-submarining latch plate **11** thereto.

By law passengers travelling in a motor vehicle or experiencing flight-turbulence must remain belted. The need for a belted mother to turn around becomes apparent, when she must attend to her children sitting on the rear seat. The separately operated release buttons **84o, 84d, 84e, 84f**, when depressed, detach only the anti-submarining latch plates **11, 25** of the lap belt portions from the assemblies **7, 8, 8a to 8d (Figs.** 1, 12b and 20) to free the mother and/or children from the anti-submarining protection while the mother and/or children remain

belted. The anti-submarining buckle assemblies **7, 8, 8a**, whose housings are located in the seat cushion **3.1, 3.1a to 3.1d**, have the common release button **84o** on the seat.

In the 1st and 2nd embodiments the multi-point seat belt **1, 1a to 1d** has a property of limited energy absorption **70, 80** which can be exploited to release energy (belt force), stored by the belt webbing, upon fracturing a number of sites of predetermined fracture in excess of the respective threshold values. The threshold values, laid out lower than the injury-relevant threshold values, are the released subenergies, the addition of which is equal to the total energy or total belt force.

A number of overlapped belt portions **1.10, 1.11, 1.12,...., 1.1n** (three overlapped belt portions shown in **Fig.** 21) is sewn together by seams $\mathbf{60_1}$ **to** $\mathbf{60_n}$, where i = 1 to n. Different threshold values of sites of predetermined fracture are achieved by

- yarns having different yield strength $\mathbf{60_1}$, $\mathbf{60_4}$, $\mathbf{60_9}$;
- single-knit seams $\mathbf{60_1}$, $\mathbf{60_2}$, $\mathbf{60_4}$, $\mathbf{60_m}$, $\mathbf{60_n}$ made from yarn sewn in single row;
- double-knit seams $\mathbf{60_3}$, $\mathbf{60_9}$ made from yarn sewn in double row and/or
- triple-knit seam $\mathbf{60_8}$ made from yarn sewn in triple row.

A number of stretching belt portions **62.1 to 62.n** and a number of overlapped belt portions **1.10, 1.11, 1.12, ... , 1.1n** (two and three overlapped belt portions shown in **Fig.** 22) are sewn together by seams $\mathbf{61_1}$ **to** $\mathbf{60_n}$, where i = 1 to n. Different threshold values of sites of predetermined fracture are achieved by

- seam stitches $\mathbf{61_1}$ **to** $\mathbf{61_4}$ having different width „w_1" to „w_4" (**Fig.** 23);
- different number of overlapped belt portions;
- yarns having different yield strength $\mathbf{61_1}$, $\mathbf{61_2}$, $\mathbf{61_3}$,...;
- stretching belt portions **62.1, 62.2, 62.3, 62.4,... 62.n**;
- single-knit seams $\mathbf{61_1}$, $\mathbf{61_4}$, $\mathbf{61_5}$, $\mathbf{61_6}$, $\mathbf{61_7}$,... made from yarn sewn in single row;
- double-knit seams $\mathbf{61_2}$, $\mathbf{61_9}$.... made from yarn sewn in double row; and/or
- triple-knit seams $\mathbf{61_f}$, $\mathbf{61_k}$ ....made from yarn sewn in triple row.

In case the restraint of the belted passenger becomes slack because of

-- the conventional belt retractor capable of retracting an excess belt portion at a total length of about 30 cm in a real-world accident or during in-flight turbulence,

- large elongation rate of the belt webbing of multi-point seat belt **1, 1a to 1d**;
- the total length of the overlapped belt portions, when being stretched, and/or
- the total length of stretching belt portions, when being stretched,

he moves out of the seat cushion and falls onto the floor. In worst case, he, when freeing himself of the restraint, can be ejected out of the motor vehicle. In order to ensure the survival chance engineers must take care of the limitation of energy absorption depending on the permissible elongation of the multi-point seat belt **1, 1a to 1d**. Tests can determine that permissible elongation up to which the multi-point seat belt always ensures the survival chance of the belted passenger in any accident. In order to absorb great energy and dampen strong vibration vibration-dampening energy absorbers must be put into use.

Care must be taken on avoiding an interference of the overlapped belt portions with the latch plates and/or D-ring when the multi-point seat belt is pro- or retracted.

„VIN" **81**, an acronym for Vehicle Identification Number, is engraved on a surface of any engraved belt portion, for example **1.11,** or affixed thereto (**Figs.** 21, 22). To conceal it from unauthorized persons, in particular car thieves, intending to manipulate, this surface is covered by a covering belt portion, for example **1.10,** and both belt portions are sewn together. If necessary, the manufacturing date can be added thereto. This feature helps Police and Insurers, getting the information only from the car corp.,

- discover and identify stolen cars having „VINs" forged by the car thieves;
- check the seat belts whether they are original ones replacing the ones worn due to great elongation in real-world accidents or during in-flight turbulence; and/or
- check the seat belts whether they are the ones approved by the car corps. There is a market for selling counterfeit seat belts, unapproved by the car corps.

Although the present invention has been described and illustrated in detail, it is clearly understood that the terminology used is intended to describe rather than limit. Many more objects, embodiments, features and variations of the present invention are possible in light of the above-mentioned teachings. Therefore, within the spirit and scope of the appended claims, the present invention may be practised otherwise than as specifically described and illustrated.